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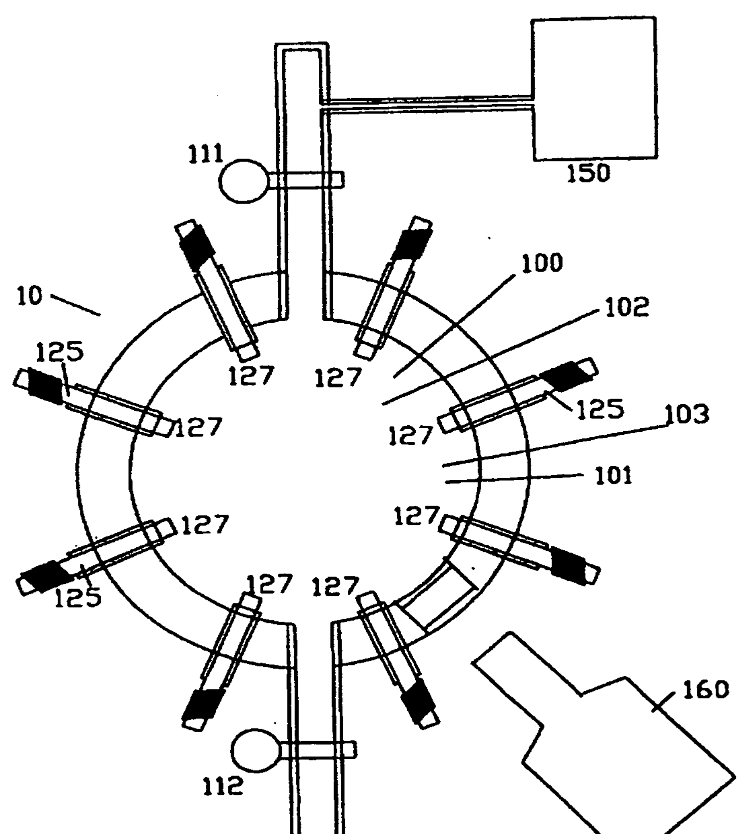
(54) Title: A METHOD FOR GENERATING NUCLEAR FUSION THROUGH HIGH PRESSURE

(57) Abstract

A method of generating nuclear fusion, whereby bubbles of a gas of about 10 micron diameter, contained in heavy water, are expanded by use of a vacuum to about 100 microns in diameter. The subsequent thermal cooling and collapse of the bubbles is augmented by a uniform pressure externally applied and acting on the bubbles through the heavy water. Symmetry in the bubbles' shape is imparted by the addition of heat from a laser as the bubbles continue to contract. High pressures and therefore temperatures are achieved, sufficient to generate nuclear fusion in specific materials.



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# Title of the Invention

A Method for Generating Nuclear Fusion Through High Pressure

# Background of the Invention

The pressure and temperature generated through the collapsing bubbles generated in sonoluminescence is well known. Recently, the creation of micro-thermonuclear fusion by sonoluminescence has been investigated by others and referenced in a number of articles. The first of these to be discussed herein is titled "Sonoluminescence and the prospects for table-top micro-thermonuclear fusion. by W.C. Moss et al.16 Nov 202015 Physics Letters A. In this study, the hydrodynamics of a collapsing bubble were investigated. The addition of pure $D_2O$ vapor lowered the speed of sound and this factor, when combined with a pressure spike added to the periodic driving amplitude created temperatures that may be sufficient to generate a very small number of thermonuclear D-D fusion reactions in the bubble. However, the release rate of energy was noted in the article to be in the order of 0.1 counts per second, an extremely small amount.

In the second article, "Shock-Wave Propagation in a Sonoluminescing Gas Bubble" by C.C.Wu et al. 31 May 202013 Physical Review Letters, Wu et al investigated the formation of shocks in a sonoluminous gas bubble of air and determined conditions where the temperature was sufficiently high to create ionization of the air with subsequent release of light energy.

In both of these cases, the expansion and collapse of bubbles comes from the phenomena of sonoluminesence and the high pressure came from shock waves. Furthermore these investigations have not and can not, achieve an energy output in excess of the input.



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While the results of both of these studies can best be described as a lab curiosity, the present invention describes a viable and effective means to change the structure of materials for the creation of viable micro-thermonuclear fusion, created through the energy of collapsing bubbles.

The present invention investigates the creation of extremely high pressure inside a bubble, not by shock wave alone but by the creation of high pressure due to expansion from rapid heating followed by collapsing due to conduction of heat to the surrounding liquid. While prior methods for which Moss and Wu investigate a curiosity, the current invention is directed towards a commercial method to generate the requisite high pressure needed to generate nuclear fusion as well as a method to generate materials such as metallic hydrogen industrial diamonds and nuclear fusion heat energy.

Also, energy levels of 1 keV are attained by Moss et al, whereas the present invention can attain much higher pressures and high temperatures above the 10keV levels by external direct compression during the contraction cycle of the bubble, to achieve the higher pressure.

Also in the case of nuclear fusion power, the present invention heats up the entire core of the collapsed bubble, instead of just at the shock front, as in Moss et al. Energy gains are calculated to exceed 1000:1 for the present invention, making it a commercially viable method for generating nuclear fusion power.

## Summary of the invention

The pressure from collapsing bubbles can generate sufficient energy to create nuclear energy fusion heat, to generate metallic hydrogen and to generate high-intensity x-rays, produce industrial grade diamonds. While all of the above and many



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more products can be achieved utilizing the energy of a collapsing bubble, the production of such products have been more of an academic or laboratory curiosity, than a valuable commercial method to generate sufficient quantity of collapsing bubbles for producing commercial quantities of resultant products. The current invention is directed towards a commercially viable product where the output exceeds the costs of input to generate commercial viable quantities of nuclear fusion energy, diamonds, metals and x-rays.

The present invention as applied to the creation of nuclear fusion heat energy conditions in a bubble of deuterium and oxygen in heavy water will generate sufficient energy that far exceeds the input energy. The method involves the creation of bubbles of deuterium and oxygen gas and injecting these bubbles into heavy water, filling a chamber with said deuterium and said oxygen in the heavy water. A vacuum is pulled on the heavy water in the chamber, to generate first the bubbles and then to cause expansion of the bubbles from 10 microns to 100 microns. An external pressure is then applied to the heavy water and subsequently transmitted to the bubbles. The bubbles collapse due to the externally applied pressure. Heating and subsequent expansion of these bubbles at 10 microns is achieved by a laser, which is used to ignite the bubble contents by selecting the correct absorption frequency, thereby imparting symmetry to the bubbles.

The rapid expansion occurring from the ignition is resisted by the progressively applied pressure and removes any assymetry in the bubble surface. Collapse of the bubbles then occurs due to heat transfer to the surrounding heavy water and the increasing externally applied pressure.

In the collapsing of the bubbles in this manner, the necessary pressures and subsequent temperatures for efficient fusion of the deuterium and oxygen, in the order



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of 5 keV and above can be achieved. Released heat is then transferred to the heavy water for conventional extraction by a heat exchanger.

The present invention can also be applied to the creation of commercially viable new materials such as diamond, high-intensity x-rays and metallic hydrogen under extremely high pressure.

Further, the present invention when utilized with superfliud helium as a media can be used as a method of accelerating particles.

## Brief Description of the Drawings

Figure 1 Illustrates an apparatus to practice the method of the invention.

Figure 2 illustrates a bubble of deuterium and oxygen in heavy water.

Figure 3 illustrates bubbles of deuterium and oxygen formed around $I_E$ crystals in heavy water.

Figure 4 illustrates the expansion of bubbles due to vacuum.

Figure 5 illustrates application of external pressure to compress the radius of the bubbles.

Figure 6 illustrates laser ignition to impart symmetry to the bubbles.

Figure 7 illustrates the compression of the symmetrical bubble to 1 micron.



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microns as illustrated in exploded view Figure 4. The precise type of value is not critical.

External pressure (127) is applied by switching on the electro-magnetic plungers (125) of Figure 2 in a controlled manner, the optimum external pressure as a function of time is described in mathematical formulas that are set forth herein and below. The bubbles (121) contract from the 100 micron to about a 10 micron size as illustrated in exploded view Figure 5 by external pressure (122). Ignition of the deuterium-oxygen gas mixture (122) inside each bubble (121) is done by a laser with the right absorption frequency either for deuterium gas or oxygen gas. The external applied heat (131) from the laser (160) in Figure 1 will cause combustion of the deuterium and oxygen gas to heavy water vapor (135) not shown.

The combustion will create high temperature and high pressure inside the bubble (121) to stop the contraction of the bubble from external pressure (127) generated by plungers (125). As shown in Figure 6, the bubbles (121) will expand slightly so that all assymetry created from the hydrodynamic instability of the contraction will be eliminated and symmetry imparted.

The heat from the heavy water vapor (135) will be conducted away by the surrounding heavy water (101). The cooling of the heavy water vapor (135) inside the bubble (121) will cause the vapor (135) to condense on the surface of the bubble (121), creating a low pressure inside the bubble (121) with very little matter.

In Figure 7, the bubble (121) collapses again to less than 1 micron radius. If the water vapor (135), not shown, does not condense on the bubble surface (126) a hard core will be developed and a shock wave will appear. Since the water vapor (135) condenses so that a hard core can not be developed and no shock wave is expected, the continual collapse of the bubble (121) will create ionization of the heavy water (101)



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Figure 8 illustrates an alternative method for injecting deuterium and oxygen gas.

## Description of the Preferred Embodiment

The following is a preferred embodiment for the creation of extreme high pressure. Creation of a mixture of deuterium gas and oxygen gas at the ration of 2:1. The known electrolysis process is applied to heavy water with DC voltage and two electrodes. Heavy water disassociates into deuterium gas and oxygen gas in the cathode and anode respectively, in exactly the ratio of 2:1. They are then gently mixed together to avoid explosion. The exact ratio is important so that when deuterium gas and oxygen gas combust to from heavy water, there is no residual gas.

Introduce the mixture of deuterium gas (102) and oxygen gas (103) in heavy water(101) under pressure, as set forth in exploded view Figure 2. The introduction can be by mixing, dissolving any way to introduce the mixture in heavy water. Preferably structured heavy water (101) with $I_E$ crystals (105) should be used as shown in exploded view Figure 3. The $I_E$ crystal (105) provides nucleation sites for the dissolved gases to form bubbles (121) when the pressure is released as seen in Figure 3.

The reaction chamber (100) of apparatus (10) in Figure 1 is filled with heavy water (101) containing the dissolved deuterium (102) and oxygen gas (103) as shown in exploded view Figure 2. The pressure is released at valves (111) and (112) as shown in Figure 1, to create bubbles (121) throughout the heavy water (101), each with a radius about 10 microns at 1 atmos pressure in Figure 3. A vacuum is then pulled on the heavy water (101) via valves (111) and (112) and vacuum pump (150) in Figure 4, so that the bubbles (121) expand from the 10 micron radius to the order of 100



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to extremely high temperatures which can be as high as 50 eV per particle. This level of temperature is sufficient for fusion to occur.

Figure 8 illustrates an alternative method to mix and form deuterium gas (202) and oxygen gas (203) bubbles (221). Deuterium gas (202) and oxygen gas (203) are mixed together precisely at a ratio of 2:1 via tubes (205) and (210) respectively and mix in tube (260) and pass into chamber (240) and pass through holes (220) to form bubbles (221) in heavy water chamber (201). This method of incorporating the bubbles can be incorporated directly into the chamber (100) shown in Figure 1.

The use of this method for the production of metals such as metallic hydrogen, the production of x-rays and diamonds is clearly achievable by using the method as set forth herein and above. For gas containing hydrogen, for example, requires energies at a minimum of 1 eV from the collapse of the bubble to form metallic hydrogen. For further example such pressure of 1 to 4 eV/atomic volume, will be sufficient for the production of diamonds. X-rays can be produced at 13.6 eV and above, with high intensity x-rays at 1 keV and above. The application of this method to various materials to alter their structure is evident to one skilled in the art. The examples of the embodiment have been set forth above for example and not limitation.

The claims follow the mathematical formulas below.

## Mathematical Formulas Illustrating the Invention

Let us consider the maximum rate of the imploding fluid that is collapsing into a bubble. The conservation of matter requires:

$$4\pi\, r^2 \rho(r) v(r) = \text{constant}$$



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Where r is the radius of the bubble, $\rho(r)$ is the density and $v(r)$ is the velocity of the imploding fluid. The velocity v of the imploding fluid on the bubble is given by:

$$v(r) = v_0(\rho_0 / \rho)\,(r^2_0/r^2) \qquad (1)$$

where $v_0$, $\rho_0$ and $r_0$ are the velocity, density and radius of the initial bubble. For an incompressible fluid we have the density constant, ($\rho_0=\rho$), and the velocity increases as the inverse of the square of the radius. The equivalent pressure p or the kinetic energy density $\varepsilon$ is equal to:

$$\varepsilon = p = 1/2\,\rho\, v^2 = 1/2\,\rho_0 v_0^2(r^4_0/r^4) \qquad (2)$$

$$\text{or} \quad \varepsilon = \varepsilon_0(r_0/r)^4 \qquad (3)$$

where $\varepsilon_0 = 1/2\rho_0 v_0^2$

i.e. the energy of the imploding fluid on the bubble increases inversely as the fourth power of the radius. When a bubble decreases from the size of 100 micron to 1 micron, the energy or equivalent pressure increases by $10^8$ or one hundred million times.

So when the bubble is created from the compressed gas inside the heavy water to about a = 10 micron size at one atmosphere ($10^5$Pa) a vacuum is pulled by one thousand times less ($10^2$Pa), the bubble size will increase approximately to $r_0$= 100 micron. Then we apply external pressure to 1 atmosphere ($10^5$Pa). In order to maintain the maximum rate of implosion it is necessary to supply increasing amounts of energy and momentum. The rate of energy increase $\varepsilon$ is given by:

$$\varepsilon = 2\pi\rho\, v_0^3 r_0^2(1- t/t_T)^{-4/3} \qquad (4)$$



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for the increase in energy $\varepsilon$, where t is the time from the contraction of the bubble and $t_T$ is a constant that is equal to total time ($t_T = r_0/3v_0$) if the fluid is allowed to collapse inward freely from radius $r_0$ at a velocity $v_0$ to the center of the bubble. If the velocity $v_0$ is about 14 m/s which is the initial velocity that comes from an external pressure of 1 atmosphere ($=10^5$ Pa) and $r_0$= 100 microns, the total time $t_T \approx 2.4$ s.

When the bubble contracts from 100 microns back to 10 microns the radius is reduced by a factor of 10 and the energy density of the imploding fluid or its pressure equivalent is increased by $10^4$ or ten thousand times or $10^9$ Pa according to the equations (2) and (3). Then the laser is turned on to ignite the deuterium and oxygen gas mixture to form heavy water vapor $D_2O$. Then it will expand slightly to eradicate all the asymmetry. The heat of combustion will be cooled off from the surrounding heavy water. The heat of combustion is proportional to the amount of gases ($D_2$+1/2$0_2$) which is proportional to the volume of the bubble or the cubic power of the radius. The cooling of the heat by the surrounding heavy water is proportional to the surface area of the bubble which varies as the square of the radius. Thus the bigger the bubble, the harder it is to for it to cool and the smaller the bubble the easier for it to cool. The critical radius can be shown to be:

$$r_c = 6C_p \rho\lambda/\{\rho_g^2 v_0 (q/\ \Delta T)^2\}$$

where:

$C_p$ = specific heat of heavy water

$\rho$ = density of heavy water around the bubble

$\rho_g$ = density of the gas inside the bubble

$v_0$ = initial velocity from collapse

$\lambda$ = conductivity of the heavy water

$q$ = heat of combustion



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$\Delta T$ = temperature difference between the surrounding fluid and the gas

An order of estimate with $\Delta T \approx 100C$ yields the value of critical radius to be about 50 microns. Our bubble is about 10 microns when the combustion of deuterium and oxygen gas occurs. So it is smaller than the critical radius. We expect the bubble will cool off and contract again.

When the bubble contracts by another order of magnitude, i.e. from 10 micron to 1 micron, the energy density or its equivalent pressure will increase another ten thousand times to $10^{13}$ Pa. Its temperature equivalent will be above 2 keV.

Since the heavy water vapor condenses on the surface of the surrounding fluid, there is no longer a strong hard core because the core will be devoid of vapor and the bubble can collapse to smaller than 1 micron. It can be estimated that if the bubble collapses additionally by 1/3, i.e. 0.36 micron, the energy density will be above 10 keV, a very hot temperature more than enough for nuclear fusion.

The energy input is tens of keV with the fusion yielding tens of MeV. We have a theoretical energy gain of 1000:1. We are different from those nuclear fusion initiated by shock wave ( Moss et al ), where only a small amount will fuse. In our scheme the whole core inside a given radius (which is 0.3 micron in the above case) will undergo nuclear fusion.



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## Claims

**I claim:**

1. A method for changing the structure of material comprising;

introducing a gas in a liquid at high pressure;

injecting said gas and liquid into a chamber;

reducing chamber pressure allowing the gas to form bubbles throughout the liquid;

pulling a vacuum inside said chamber to allow the bubbles to expand;

applying an external pressure on said bubbles to reduce said bubbles' volume;

adding heat energy to said bubbles to impart symmetry to said bubbles' shape;

continuing to apply pressure to said bubbles, further reducing said bubbles' volume until the pressure inside said bubbles exceed the applied pressure.

2. The invention of claim 1 wherein said heat energy is applied utilizing a laser.

3. The invention of claim 1 wherein said heat energy is applied utilizing hydrocarbon.

4. The invention of claim 1 wherein said liquid utilized to introduce said gas in is water.

5. The invention of claim 1 wherein said liquid utilized to introduce said gas in is heavy water.

6. The invention of claim 1 wherein said continuing applying pressure to said bubble further reducing said bubble's volume until the pressure inside said bubbles being a minimum of 1 eV per particle.



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7. The invention of claim 1 wherein said continuing applying pressure to said bubble further reducing said bubble's volume until the pressure inside said bubbles being a minimum of 13.6 eV per particle.

8. The invention of claim 1 wherein said continuing applying pressure to said bubble further reducing said bubble's volume until the pressure inside said bubbles being a minimum 1 keV per particle.

9. The invention of claim 1 wherein the external pressure is monotonically increasing.

10. The invention of claim 1 wherein said heat energy is generated by an absorption of laser at the characteristic frequency of the material in the bubble.

11. The invention of claim 3 wherein said hydrocarbon is benzene.

12. The invention of claim 6 wherein said gas contains hydrogen.

13. The product of the method of claim 20 being metallic hydrogen

14 The invention of claim 6 wherein the gas contains carbon.

15. The product of the method f the invention of claim 14 being diamond.

16. The product of the invention of claim 7 being x-rays.

17. The product of the invention of claim 8 being high intensity coherent x -rays.

18 The invention of claim 8 wherein gas contains deuterium and oxygen gas.



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19. The product of the invention of claim 18 being nuclear fusion heat.

20 A method for changing the structure of materials under high pressure comprising;

introducing gas in a liquid at a high pressure;

introducing said gas and said liquid into a chamber;

reducing said chamber pressure allowing said dissolved gas to form bubbles throughout said liquid;

pulling a vacuum inside said chamber to allow said bubbles to expand;

applying an external pressure on said bubbles to reduce said bubbles' volume;

adding heat energy to the bubbles to impart symmetry in said bubbles' shape;

continuing to apply pressure to said bubbles further reducing their volume until the pressure inside the bubbles is a minimum of 1 eV per particle.

21. The invention in claim 20 wherein said gas contains carbon.

22. The invention in claim 20 wherein said gas contains hydrogen.

23. The invention in claim 20 wherein said heat energy is applied utilizing a laser.

24. The invention in claim 20 wherein said heat energy is applied utilizing hydrocarbon.

25. The invention in claim 20 wherein said liquid utilized to introduce said gas in is water.

26. The invention in claim 20 wherein said liquid utilized to introduce said gas in is heavy water.



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27. The invention in claim 20 wherein said continuing applying pressure to said bubble further reducing said bubble's volume until the pressure inside said bubble is a minimum of 13.6 eV per particle.

28. The invention of claim 27 wherein the gas contains deuterium gas and oxygen gas.

29. The product of the invention of claim 28 being coherent x-rays.

30. The invention in claim 20 wherein said continuing applying pressure to said bubble further reducing said bubble's volume until the pressure inside said bubble is a minimum of 1 KeV per particle.

31. The invention in claim 20 wherein the external pressure is monotonically increasing.

32. The invention in claim 20 wherein said heat energy is generated by an absorption of laser at the characteristic frequency of the material in the bubble.

33. The invention of claim 24 wherein said hydrocarbon is benzene.

34 The invention of claim 27 wherein said gas contains deuterium gas and oxygen gas.

35. The invention of claim 32 wherein said deuterium gas and said oxygen gas is ignited to form heavy water gas.

36 The invention of claim 20 wherein said gas contains deuterium gas and oxygen gas.



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37. A method for generating high pressure inside a bubble, comprising;

generating bubbles in a fluid;

contracting said bubbles in said fluid by external pressure;

applying heat during the compression to impart symmetry.

38. The product of the invention of claim 37 being nuclear fusion heat.



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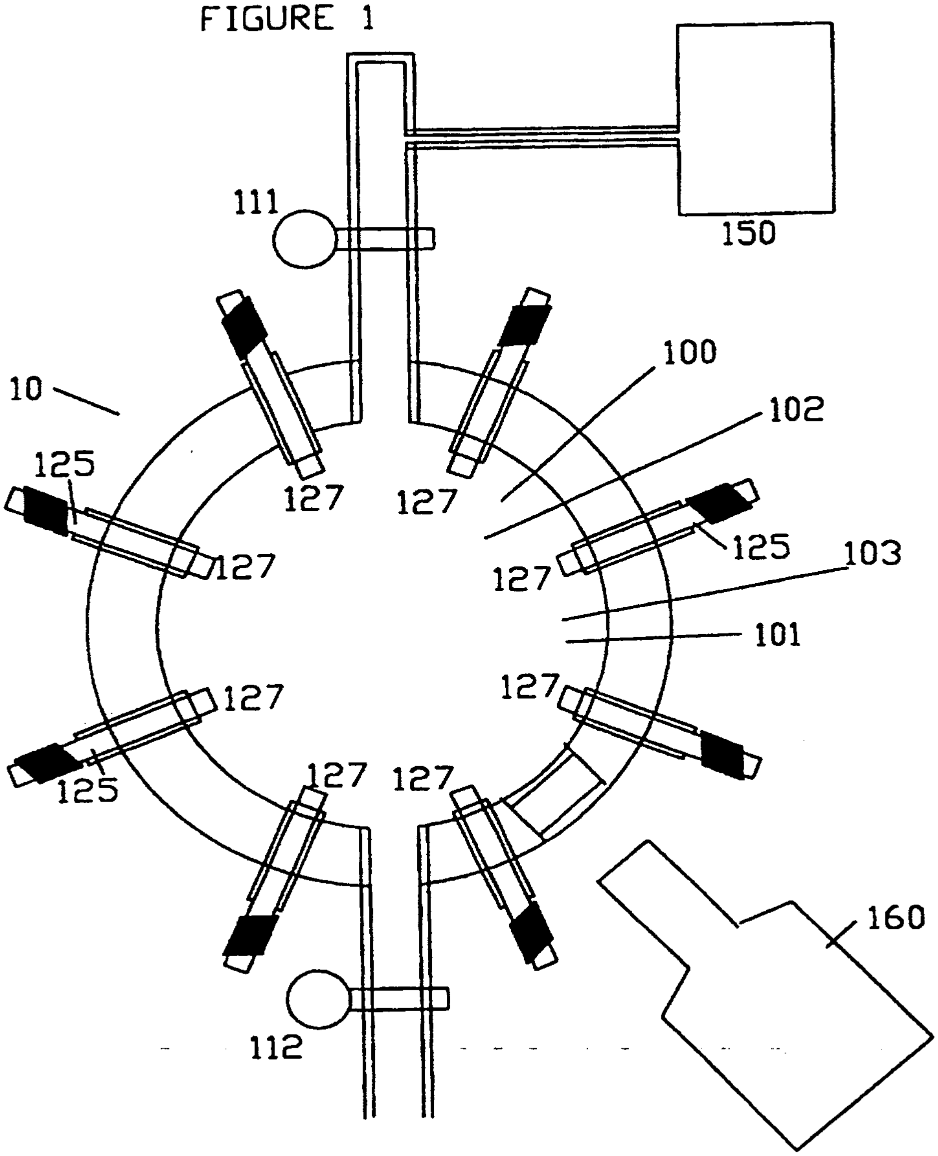
FIGURE 1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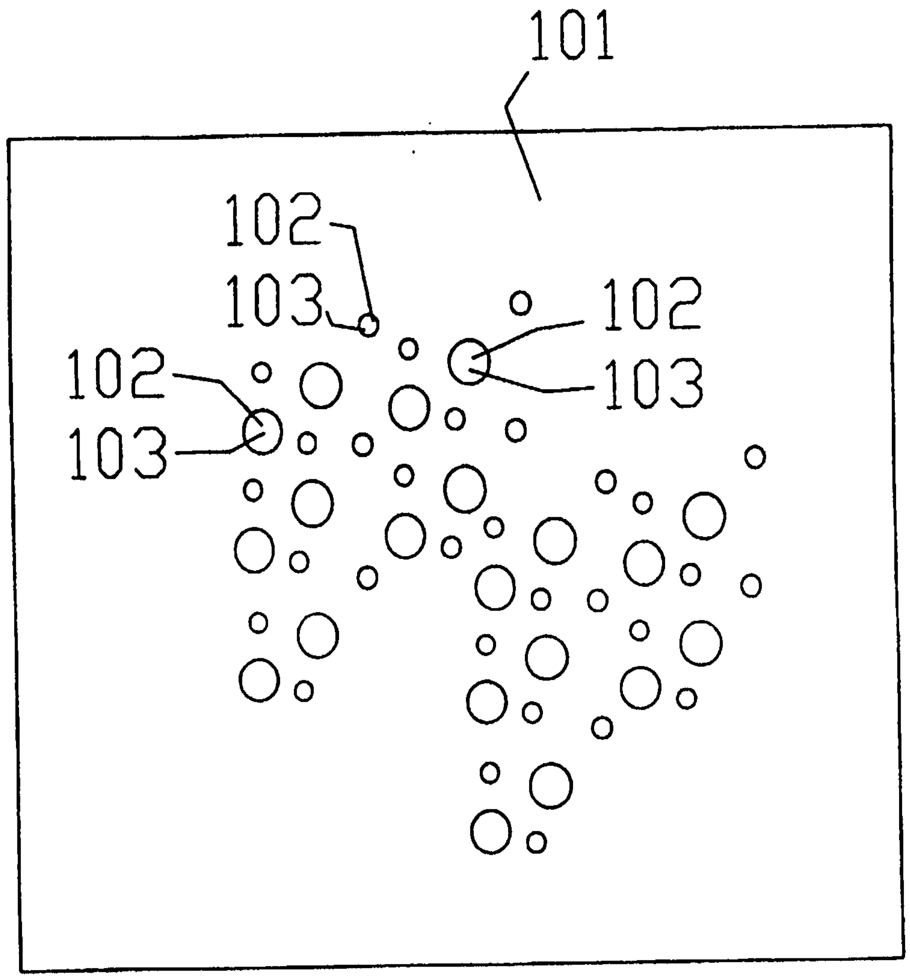


FIGURE 2 DEUTERIUM AND OXYGEN DISSOLVED IN HEAVY WATER

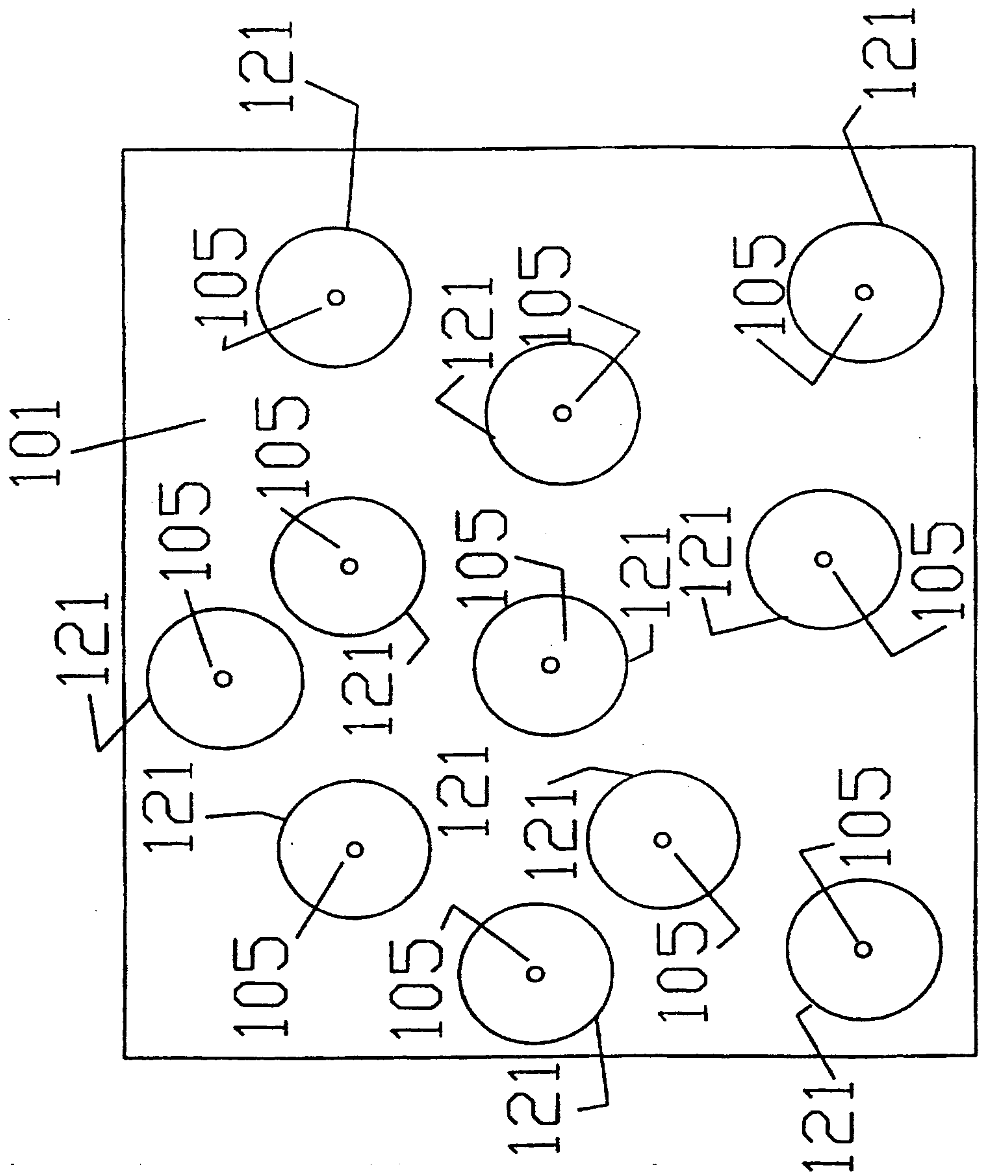


FIGURE 3 BUBBLES FORMED AROUND IE CRYSTALS IN HEAVY WATER

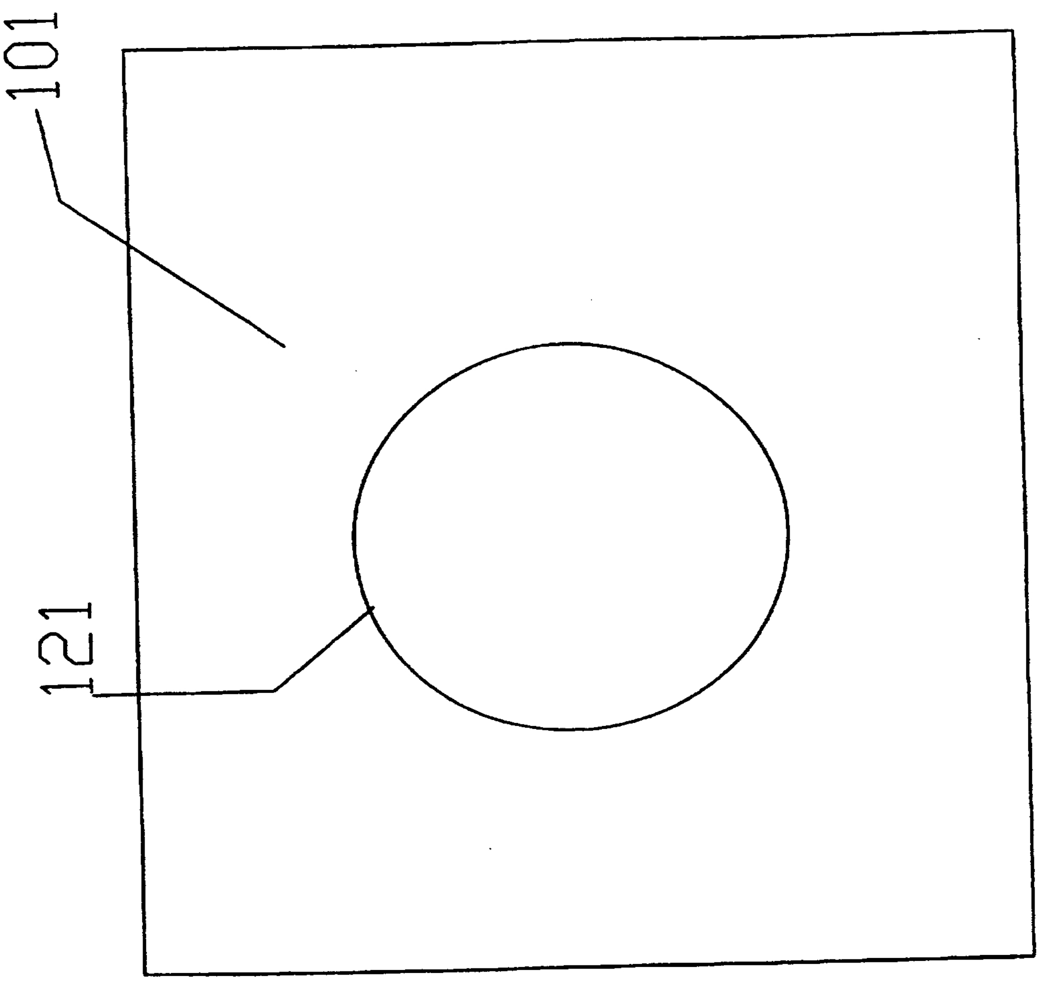


FIGURE 4 BUBBLE RADIUS
EXPANDED TO 100 MICRONS

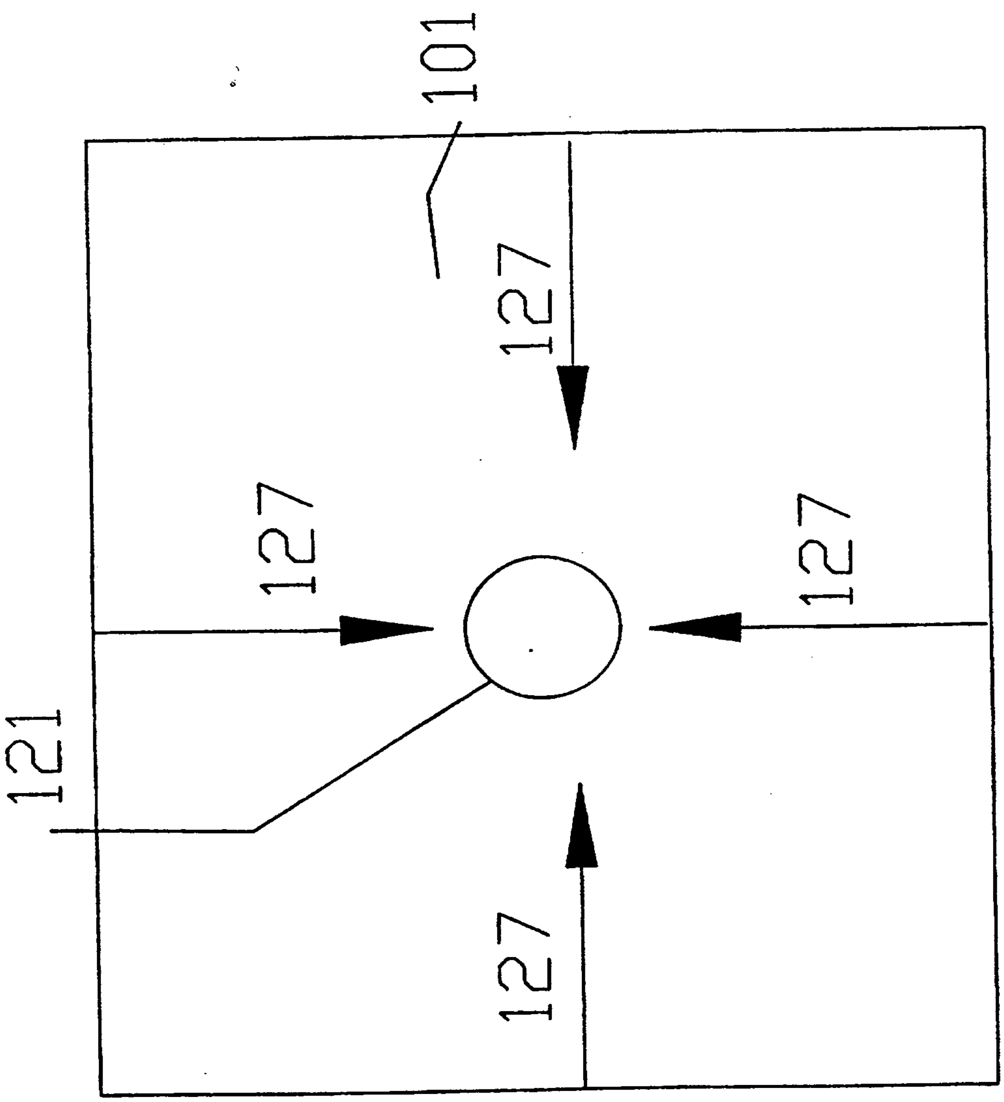


FIGURE 5 COMPRESSION CYCLE TO RADIUS OF 10 MICRONS

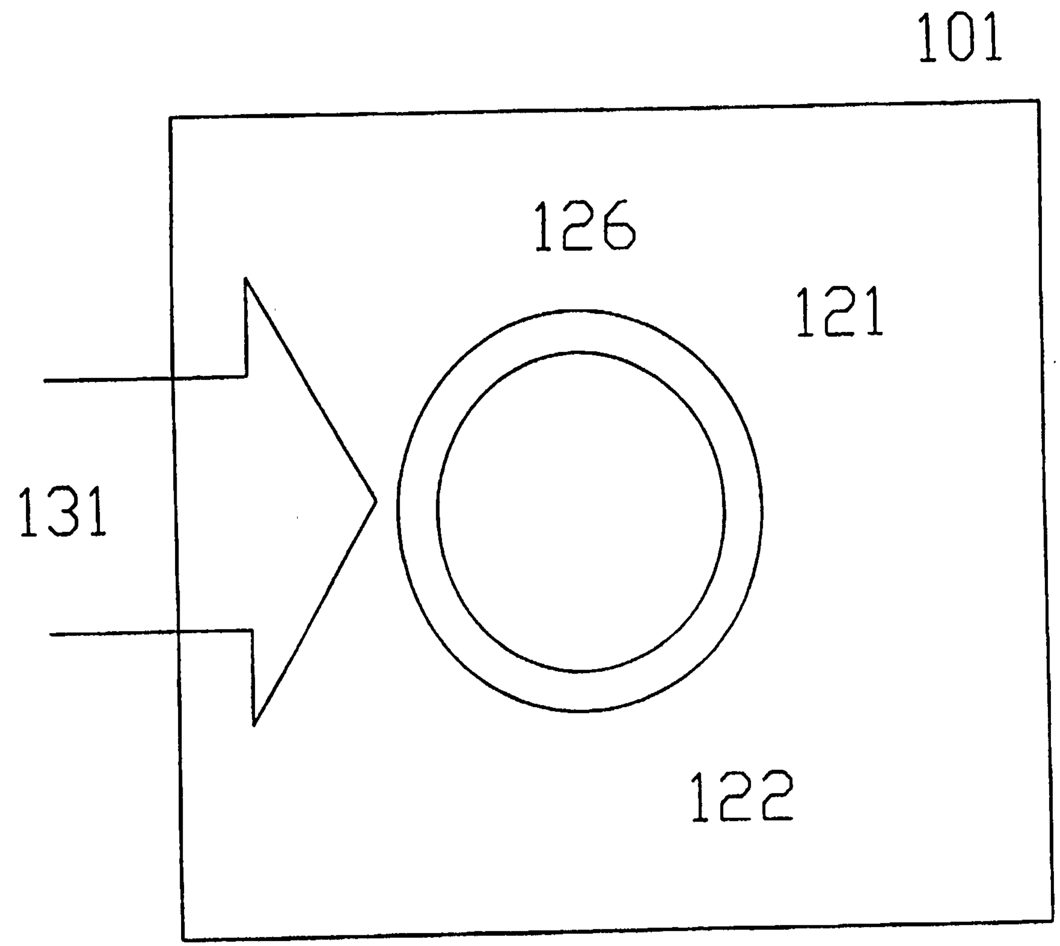


FIGURE 6 LASER IGNITION TO EXPAND RADIUS AND ERADICATE ASSYMETRY

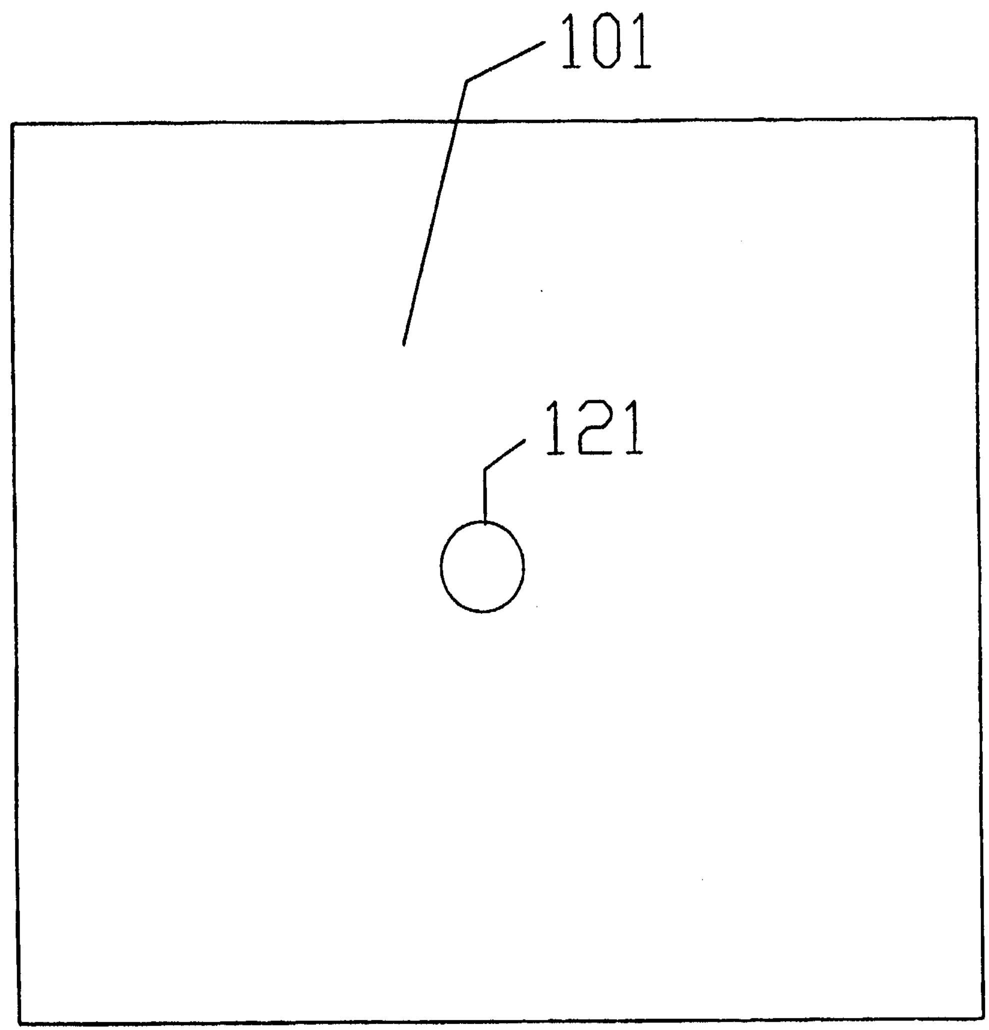


FIGURE 7 COMPRESSION TO RADIUS OF 1 MICRON

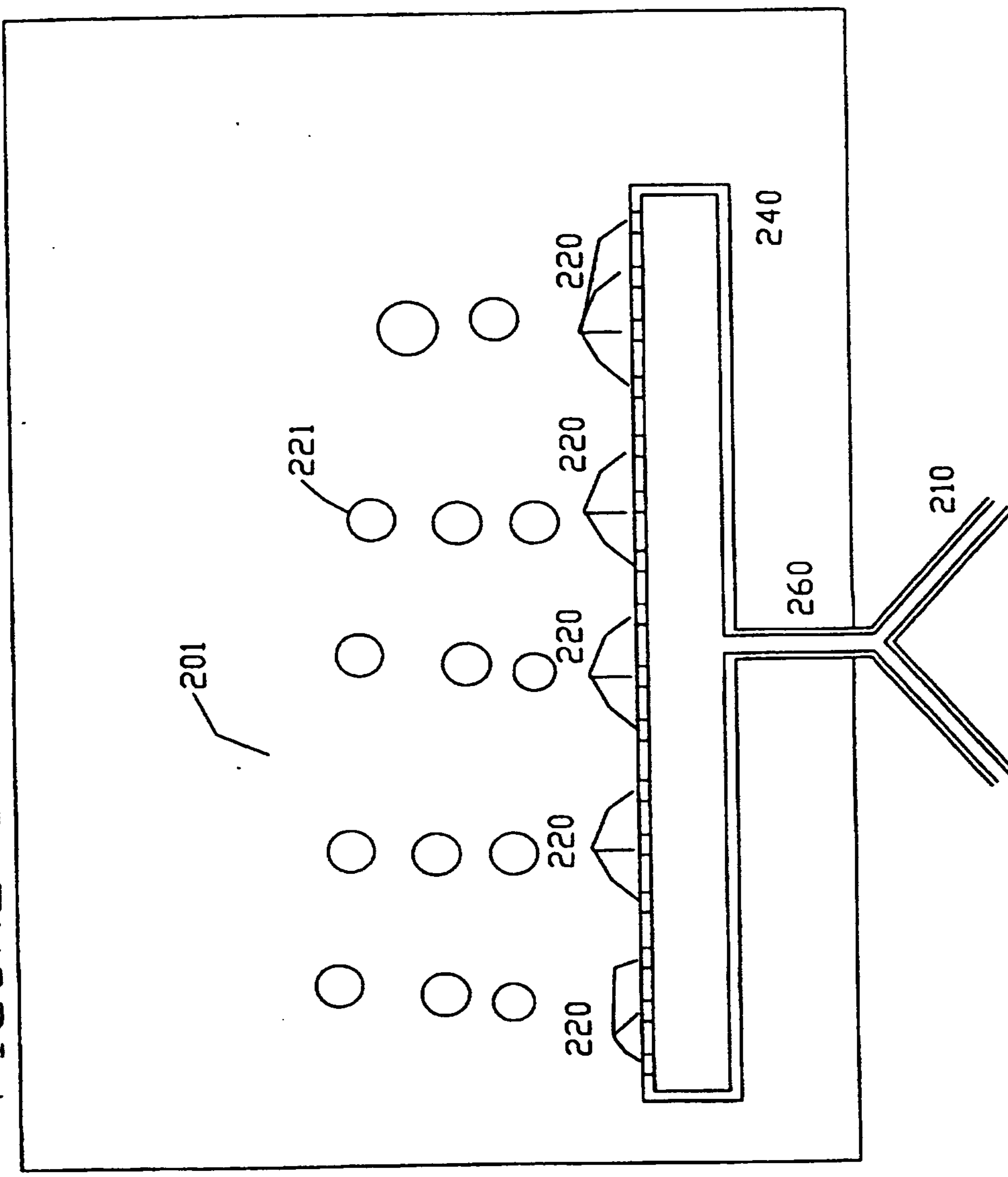


FIGURE 8 MIXING OF GASES

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